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Colorfastness of Naturally-Dyed Fabrics Using Contact Dyeing Method

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Compared to synthetic dyes, natural dyes produce a limited variety of colors with soft, irregular shadings (Shams-Nateri, Hajipour, Dehnavi, & Ekrami, 2014). Natural dyes are restricted to artisan, craftsmanship, or small scale mainly because colorfastness of natural dyes is not like those of chemical dyes in large-scaled dyeing techniques producing moderate to excellent colorfastness. To improve colorfastness, natural dyes are still exclusively used with chemical mordants, commonly containing aluminum, which produce unsafe wastewater from the dyeing process (Haar, Schrader, & Gatewood, 2013). A substantial amount of water is also wasted during the dyeing process, making the process of natural dyeing unsustainable.

The use of the contact dyeing method and natural mordants may have potential for reducing wastewater and developing a more sustainable method for natural dyeing (Kadolph & Casselman, 2004). Contact dyeing, known as *no pot dyeing*, is an alternative of immersion dyeing by creating bundles using natural materials and a low liquor ratio method. Kadolph and Casselman (2004) suggest contact dyeing can be an eco-friendlier dyeing method with benefits of lower costs, less equipment, less labor, safer procedures, and smaller consumption of water than immersion dyeing. Although contact dyeing is suggested, the use of natural dyes through a contact dyeing method is still very limited, due to a lack of standard color retention and colorfastness. Prior research identified different dyeing methods for natural dyes in relation to mordant concentration, mordanting procedures, and heating time influenced coloration and colorfastness (Li, Malensek, Sarkar, & Xiang, 2016; Shams-Nateri et al., 2014). However, few studies have investigated colorfastness of naturally-dyed fabrics using a contact dyeing method with a natural mordant. Thus, the purpose of this study was to examine colorfastness of naturally-dyed fabrics using contact dyeing and a natural mordant in relation to different mordant concentrations, mordanting procedures, and heating time.

Plain-woven cotton fabrics, purchased from Testfabrics Inc., were utilized: 107g/m² weight, 150 count, 0.356 mm thickness, bleached, and mercerized. Mashed blueberries mixed with a very low liquor ratio of water were sprayed on these cotton fabrics. Vinegar was used as a mordant. Despite Kadolph and Casselman's suggestion to use copper as a mordant with fruit, vinegar is a more sustainable option, since copper compounds raise concerns about toxicity (Haar et al., 2013). Different concentrations of 25, 50, and 100% were used in addition to specimens with no mordant. If mordant was added, it was completed as a pre-dyeing treatment, consecutively with the contact dyeing, or a post-dyeing treatment. After dyeing, specimens were heated in a microwave for 10, 15, or 20 minutes and air-dried before colorfastness testing. AATCC 61 Colorfastness to laundering was conducted to test naturally-dyed fabrics in relationship with the concentration of mordant used, the stage in the dyeing process when the mordant was added, and the amount of time specimens spent being heated during the dyeing

process. One-way between groups ANOVAs were conducted to examine how colorfastness to laundering differs, depending on the different dyeing methods, using IBM SPSS Statistics 22.0.

Results indicated no significant differences in color change for the different mordant concentrations, $F(3, 76)=.49, p > .05$, as well as for the different mordanting procedures, $F(3, 76)=.065, p > .05$. However, there were statistically significant differences in color change for the different times exposed to heat: $F(3, 76)=17.87, p < .001$. The mean score for no heating ($M=1.6, SD=.88$) was lower than those for 10 min. heating ($M=2.4, SD=.75$), 15 min. heating ($M=2.76, SD=.70$), and 20 min. heating ($M=3.356, SD=.73$). Specimens exposed to longer heating tended to have less color change when evaluating the specimens by the gray scale for color change. For staining on cotton, no significant differences were detected by the different mordant concentrations, $F(3, 76)=1.50, p > .05$. However, statistically significant differences were found by the different mordant procedures, $F(3, 76)=3.00, p < .05$ as well as by the different heating times, $F(3, 76)=12.11, p < .001$. Pre- and post-mordant procedures ($M=2.98, SD=.71$; $M=2.98, SD=1.12$, respectively) tended to have less staining on cotton than non- and consecutive-mordant procedures ($M=2.25, SD=1.71$; $M=2.25, SD=1.05$, respectively). The 20 min. heating ($M=1.98, SD=.70$) tended to have more staining on cotton than 10 min. heating ($M=2.30, SD=.86$), 15 min. heating ($M=2.85, SD=.71$), and no heating ($M=3.63, SD=1.31$).

Overall, results indicate time exposed to heat had significant impact on color change and staining on cotton rather than the mordant concentrations and the mordant procedures. Time exposed to heat could enhance colorfastness of contact-dyed fabrics to laundering in relationship to color change. Pre- and post-mordanting procedures may also reduce staining on other cotton fabrics. However, overall colorfastness of the contact-dyed cotton fabrics was poor to moderate. Besides, long exposure in the microwave may waste more energy although using vinegar, contact method of dyeing, and natural dyes all focused on sustainability. Because colorfastness to laundering was below acceptable AATCC performance standards for applicable apparel products, further research is needed to improve colorfastness of contact-dyed fabrics to laundering as well as to expand the use of sustainable contact-dyeing for consumers and the environment.

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